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# The coronavirus outbreak in the Netherlands: a business cycle accounting analysis

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## Abstract

This paper employs the business cycle accounting framework to investigate the underlying mechanisms driving economic fluctuations during the coronavirus outbreak in the Netherlands. Our findings suggest that the efficiency wedge plays the primary role in explaining output behaviour, followed by the labour wedge. Government financial measures contributed to the inefficient utilisation and allocation of input factors, leading the economy to a downturn. The investment and government wedges present a negligible impact on output variations. In contrast, an economy without the efficiency wedge accounts for most movements in hours worked, while the labour wedge is essential for understanding investment dynamics.



**Keywords:** Business Cycle Accounting; coronavirus; economic crisis; efficiency wedge; Netherlands; productivity



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# 1 Introduction

On May 5th, 2023, the Director-General of the UN World Health Organization (WHO) declared the end of the coronavirus outbreak as a global health emergency, despite the virus still being an ongoing risk. At that time, WHO Coronavirus Dashboard registered over 765 million confirmed cases, with approximately 7 million reported fatalities. The implications created by the pandemic were not only health-related, but also economic, societal, and political. The global economy was caught unprepared, as supply chains disrupted around the world. Policymakers faced a dire dilemma between safeguarding people's lives and sustaining economic activities. Bollino (2023) found that the restrictive measures implemented in the European Union (EU) countries yielded an economic cost of 218 thousand euros per human life saved.

The Netherlands was not immune to the pandemic repercussions. As one of Europe's most densely populated countries, it recorded almost 23 thousand deaths and roughly 8.6 million confirmed cases. In an effort to protect vulnerable populations and control the spread of the virus, the Dutch authorities adopted a series of containment measures, which relied on their citizens' sense of responsibility. The so-called 'intelligent lockdown' differed from the measures applied in other EU countries. Rather than imposing strict lockdown orders, the government encouraged social distancing, remote work, face mask-wearing, and the avoidance of large gatherings. Furthermore, hospitality services and schools were temporarily closed, and visits to nursing homes were prohibited. These relatively mild policies reduced activities outdoors by 80% (De Haas, Faber, and Hamersma 2020), in particular among the elder generation. Nevertheless, as the infection rate rose, the Netherlands narrowed its measures to more stringent ones.[1]

Part of the economy came to a halt. The containment measures, combined with the sharp decline in international trade, caused economic activity to fall by 3.9% in 2020 (World Bank 2024), a less severe contraction than the one felt by the neighbouring countries. Both consumer

1. For more details about the COVID-19 government response in the Netherlands, see figure 5 in the Appendix.

spending and production were severely impacted, especially in high-contact industries. Strong economic infrastructures and effective government financial support were crucial in alleviating the economic fallout, with the unemployment rate rising slightly and the number of bankruptcies showing no increase in the first half of 2020 (Hoekman, Smits, and Koolman 2020). The fiscal packages included, but were not limited to, wage subsidy schemes, reimbursement of fixed costs programs, direct compensation to affected sectors, tax reliefs, and support for entrepreneurs.

Given the unprecedented magnitude and nature of the shock, interested researchers have struggled to construct quantitative models that capture the dynamics of the coronavirus crisis. Fortunately, the business cycle accounting (BCA) framework, first introduced by Chari, Kehoe, and McGrattan (2002), emerges as a valuable instrument in identifying the most promising class of models to replicate and comprehend a given episode of economic fluctuations. Therefore, by applying the BCA procedure, our paper seeks to shed light on potential transmission mechanisms driving economic variations during the 2019:Q4 to 2021:Q4 period in the Netherlands. We also hypothesise on a potential narrative to explain the roles of each contributing factor.

The BCA framework consists of two key components. First, the accounting procedure estimates the four time-varying wedges—namely, efficiency, labour, investment, and government—by inputting the observed data into the equilibrium conditions of the prototype economy. Afterwards, simulations are conducted to investigate the relative significance of a specific wedge, or set of wedges, for the dynamics of the economic variables, such as output, hours worked, and investment. The estimated wedges are then fed back into the model, either individually or in combination, while the remaining ones are kept constant. Using these linear decompositions, we are able to gain insights regarding the short-run drivers through which the pandemic affected economic variables. Finally, the equivalent result suggests that a time-varying wedge in a prototype economy can be mapped to a set of frictions in a detailed economy.

Our findings indicate that the efficiency wedge is the primary contributor to output fluctuations during the coronavirus crisis in the Netherlands, followed by the labour wedge. Financial systems may have undermined the efficiency wedge and, consequently, output, as fiscal stimulus hindered the efficient utilisation and allocation of input factors across heterogeneous firms. In contrast, the investment and government wedges have a negligible impact on output behaviour. An economy without the efficiency wedge accounts for most movements in hours worked, while the labour wedge plays a crucial part in explaining variations in investment.

The remainder of the paper is organised as follows: Section 2 offers a brief overview of the existing BCA-related literature. Section 3 introduces the BCA theoretical framework, presenting the prototype economy and its estimation method. Section 4 details the data sources and variables employed, as well as the transformations applied to them. Section 5 describes and analyses the results obtained from applying the BCA exercise to the Dutch economy during the coronavirus crisis. Section 6 provides concluding remarks and proposes further research.

## 2 Background

Real Business Cycle (RBC) modelling, pioneered by Kydland and Prescott (1982), serves as a valuable instrument in macroeconomics for studying fluctuations in economic variables. However, model predictions do not always replicate empirical regularities. Although data mismeasurement could be a factor, the most plausible explanation for the discrepancy between predicted and observed data would be that neoclassical models require modifications to encompass distortions. Christiano and Eichenbaum (1992), for instance, adjusted a prototypical RBC model to capture the correlation between hours worked and the return to working by enabling government consumption shocks to impact labour-market dynamics.

Researchers face a challenge when constructing quantitative models. Which frictions should be incorporated into the perfect competition market model to bring it closer to conformity with the empirical data? The BCA framework emerges in Chari et al. (2002) as a useful guide to pinpoint the driving mechanisms behind business cycle fluctuations. In other words, this method helps researchers grasp the most promising theories for explaining economic movements. Although Chari, Kehoe, and McGrattan (2005) introduced a government wedge in the prototype model, the BCA theoretical framework, inspired by growth accounting methods (Abramovitz 1956; Solow 1957), was not fully developed until later in Chari, Kehoe, and McGrattan (2007a).

In this last paper, the authors employed the BCA framework to evaluate two pivotal crises in the United States economy: the Great Depression and the 1982 recession. Since then, this methodology has been used to examine several business cycle episodes across various countries. In Europe, for example, Iskrev (2013) conducted a BCA analysis to study economic distortions in Portugal from 1998 to 2012. Meanwhile, Bridji (2013) explored business cycle variations during the French Great Depression. López and García (2016) investigated two cyclical episodes in Spain: the transition to democracy in 1977 and the 2008 Great Recession.

Nevertheless, the existing BCA literature concerning the Netherlands appears to be somewhat scarce. Brinca et al. (2016) assessed the same economic downturns as Chari et al. (2007a); however, the authors applied the framework to the OECD countries. Their research revealed that, in the context of the Netherlands, the efficiency wedge was the dominant factor behind the output dynamics during the Great Recession. In contrast, the contributions from the investment and labour wedges were relatively negligible. These findings align with those of Gerth and Otsu (2018), who argue that credit crunches deteriorate aggregate production efficiency due to resource misallocation. In the meantime, during the 1982 recession, the efficiency wedge exhibited a less significant role, with the investment wedge emerging as the primary driver of output behaviour. The $\phi$-statistics for the efficiency and investment component of output, which will be discussed in more detail later, were 34% and 44%, respectively (Brinca et al. 2016).

Christiano and Davis (2006) critiqued the BCA framework on two main grounds. First, they argued that the framework lacks robustness to minor changes in the environment. Financial shocks may manifest in the form of the efficiency wedge rather than the investment wedge (Mendoza 2010), thereby undermining the latter's contribution. In consequence, certain classes of models are left out of the promising candidates' list. Instead of relying on the investment wedge, they proposed the introduction of a new distortion, which acts as a tax on the gross rate of return on capital. This so-called capital wedge not only provides a more accurate representation of the prototype economy, but also has a more significant role in explaining short-run economic movements. Second, some spillover effects may be overlooked, as this approach focuses on the driving mechanisms and not on the primitive source of the shock. As such, a single wedge may reflect a combination of different shocks.

Chari, Kehoe, and McGrattan (2007b) responded to the criticism put forth by Christiano and Davis (2006). The authors emphasised that the equilibrium allocation remains unchanged, irrespective of whether an investment or a capital wedge was employed. They also claimed that their methodology is firmly grounded in well-established theoretical literature. Finally, through the application of a variance decomposition of forecast errors, their findings suggested that the investment wedge captures a moderate portion of the financial shocks.

The underlying theoretical framework has been extended over the years to incorporate additional dimensions. One modification is the open-economy BCA (Hevia 2014; Lama 2011; Otsu, 2010a), which adapts the prototype economy in order to reflect a small open-economy framework. Meanwhile, the monetary BCA (Šustek 2011) addresses monetary concerns by including the nominal interest rate and inflation in the prototype economy. The international BCA (Otsu, 2010b) works with a two-country model to study international relations.

## 3 Methodology

The BCA procedure is divided into two main components: an accounting procedure, from which the framework gets its name, and an equivalent result.

The wedges represent the deviation of observed data from the neoclassical growth model estimates. In the accounting procedure, the four time-varying wedges are computed by incorporating actual data on the equilibrium conditions. Each wedge is named according to the condition it distorts. The efficiency wedge appears within the production function as a technology parameter. The investment wedge is represented by a time-varying tax on investment, impacting the intertemporal allocation between present consumption and savings. Furthermore, the labour wedge twists the optimal labour choice by manifesting as a time-varying tax on the marginal product of labour. This last wedge considers both labour supply and labour demand distortions, making it difficult to identify its underlying source. Finally, the government wedge modifies the aggregate resource constraint through government expenditure. It is important to note that, for open economy models, this wedge also takes net exports into account.

Nevertheless, researchers must be cautious when assigning wedge variations exclusively to the variable referenced in their nominal names. Mendoza (2010) demonstrated that input-financial frictions may manifest themselves as the efficiency wedge instead of the investment wedge. A wedge reflects the cumulative effect of all shocks impacting a given margin and can arise from one or multiple structural shocks. As such, it does not indicate the primitive source of the shock but rather highlights the underlying driving mechanisms. In consequence, the most relevant wedge will point to the most promising class of models for explaining economic performance, rather than identifying a specific model with particular frictions.

Once measured, business cycle fluctuations are linearly decomposed to isolate the marginal effects of each distortion, or combination thereof. The wedge values are subsequently reintroduced into the prototype economy, either individually or in groups, while fixing the rest at their steady-state levels. The paths of economic variables, such as output, investment, and hours worked, are simulated. By comparing the various simulations, we can evaluate the quantitative relevance of each wedge and shed light on the potential transmission mechanisms behind this cyclical episode. It is important to note that by construction the combined effect of all wedges accounts for the overall movement observed in the data, thereby ensuring that the equilibrium conditions are satisfied. Therefore, when all wedges are fed back into the prototype economy, the simulation fully mirrors the entire economic dynamics.

Models are considered equivalent when their equilibrium conditions are identical. This way, the equivalent result suggests that a large set of detailed economies with frictions can be traced to a prototype economy with time-varying wedges. For instance, a detailed economy featuring working capital constraints (OBCA) can be mapped to a prototype economy with an efficiency wedge (Christiano, Gust, and Roldos 2004). Chari et al. (2007a) and Brinca et al. (2016) have theoretically demonstrated several equivalent results between detailed economies and the prototype economy.[2] As such, researchers can identify the most relevant class of models to help them construct quantitative models that replicate economic movements for their focus period.

### 3.1 Prototype Economy

The neoclassical growth model, presented by Chari et al. (2007a), serves as the foundation for our benchmark prototype economy. The economy experiences a finite sequence of events, denoted as $s_t$. The probability of any history of events up to period $t$, $s^t = (s_o, ..., s_t)$, is represented by $\pi(s^t)$. It is important to mention that the initial state, $s_0$, is predetermined. In this perfectly competitive market model, agents rationally decide the resource allocation in each period $t$, based on the current and past states. The economy is distorted by four time-varying wedges: the efficiency wedge, $A_t(s^t)$, the labour wedge, $1 - \tau_{l,t}(s^t)$, the investment wedge, $1/[1 + \tau_{x,t}(s^t)]$, and the government wedge, $g_t$.

The household's objective within this framework is to maximise his expected lifetime utility with respect to consumption *per capita*, $c_t$, and labour *per capita*, $l_t$, for each $t$ and $s^t$:

2. An exhaustive list of equivalent results can be found in Brinca, Costa Filho, and Loria (2024).

$$\sum_{t=0}^{\infty}\sum_{s^t}\beta^t\pi(s^t)U(c_t(s^t),l_t(s^t))N_t \tag{1}$$

where $\beta$ stands for the discount factor, $U(.)$ for the utility function of the representative household, which is expressed as $U(c_t(s^t),l_t(s^t)) = ln[c_t(s^t)] + \psi ln[l_t(s^t)]$, with $\psi$ being the time allocation parameter, and $N_t$ is the population size, whose growth rate is given by $\gamma_n$. The household's problem is subject to the intratemporal budget constraint:

$$c_t(s^t) + [1+\tau_{x,t}(s^t)]x_t(s^t) = [1-\tau_{l,t}(s^t)]w_t(s^t)l_t(s^t) + r_t(s^t)k_t(s^t) + T_t(s_t) \tag{2}$$

where $x_t$ denotes the investment *per capita*, $w_t$ the real wage rate, $r_t$ the rate of return on capital, and $T_t$ the lump-sum transfers from the government to households *per capita*. Capital accumulates according to the law of capital ($k_t$) accumulation with adjustment costs $\phi(\frac{x_t(s^t)}{k_t(s^{t-1})})$, which follows Brinca et al. (2016):

$$(1+\gamma_n)k_{t+1}(s^t) = (1-\delta)k_t(s^{t-1}) + x_t(s^t) - \phi(\frac{x_t(s^t)}{k_t(s^{t-1})}) \tag{3}$$

where $\delta$ is the depreciation rate, the adjustment costs $\phi(\frac{x_t(s^t)}{k_t(s^{t-1})})$ equals to $\frac{a}{2}(\frac{x_t(s^t)}{k_t(s^{t-1})} - b)^2$, where $b = \delta + \gamma + \gamma_n$ corresponds to the steady-state value of the investment–capital ratio and $\gamma$ is the technological growth rate, which is set such that, over the sample period, detrended log GDP per working age population is mean zero.

Simultaneously, the representative firm aims to maximise their profit, $\Pi_t$, in relation to stock capital *per capita*, $k_t$, and labour *per capita*, $l_t$, for each $t$ and $s^t$:

$$\Pi_t(s^t) = y_t(s^t) - w_t(s^t)l_t(s^t) - r_t(s^t)k_t(s^{t-1}) \tag{4}$$

with $y_t$ being the output *per capita*.

Finally, the government decides transfers and taxes such that its budget constraint at $t$:

$$G_t(s^t) + T_t(s^t) = \tau_{x,t}(s^t)x_t(s^t)N_t + \tau_{l,t}(s^t)w_t(s^t)l_t(s^t)N_t \tag{5}$$

is satisfied, with $G_t$ representing the government spending.

The four equilibrium conditions for the prototype economy can be found below:

$$y_t(s^t) = A_t(s^t)F(k_t(s^{t-1}), (1+\gamma)^t l_t(s^t)) \tag{6}$$

$$y_t(s^t) = c_t(s^t) + x_t(s^t) + g_t(s^t) \tag{7}$$

$$-\frac{U_{l,t}(s^t)}{U_{c,t}(s^t)} = [1 - \tau_{l,t}(s^t)]A_t(s^t)(1+\gamma)F_{l,t} \tag{8}$$

$$\begin{aligned} U_{c,t}(s^t)[1 + \tau_{x,t}(s^t)] = \beta \sum_{s^{t+1}} \pi_t(s^{t+1}|s^t)[U_{c,t+1}(s^{t+1})(A_{t+1}(s^{t+1})F_{k,t} \\ + (1-\delta)[1 + \tau_{x,t+1}(s^{t+1})] + \phi_{k_{t+1}}] \end{aligned} \tag{9}$$

where $F(.)$ is the production function with constant returns to scale, which is characterised by $F(k_t(s^{t-1}), (1+\gamma)^t l_t(s^t)) = k_t(s^t)^{\alpha}[(1+\gamma)^t l_t(s^t)]^{1-\alpha}$, where $\alpha$ is the share of capital. $U_{l,t}$, $U_{c,t}$, $F_{l,t}$, $F_{k,t}$, and $\phi_{k_{t+1}}$ are the first order conditions of the utility function, production function, and adjustment costs regarding their arguments.

The equilibrium conditions represent the production technology, the aggregate resource constraint, the intratemporal decision equation between labour and leisure, and the intertemporal decision equation between consumption and savings, respectively. Each condition is associated with a given wedge. As such, the equations can be rearranged to directly solve for the wedges:

$$A_t(s^t) = \frac{y_t(s^t)}{F(k_t(s^{t-1}),(1+\gamma)^t l_t(s^t))} \tag{10}$$

$$g_t(s^t) = y_t(s^t) - c_t(s^t) - x_t(s^t) \tag{11}$$

$$[1-\tau_{l,t}(s^t)] = -\frac{U_{l,t}(s^t)}{U_{c,t}(s^t)}(A_t(s^t)(1+\gamma)F_{l,t})^{-1} \tag{12}$$

$$\begin{aligned}\frac{1}{[1+\tau_{x,t}(s^t)]} = U_{c,t}(s^t)(\beta \sum_{s^{t+1}} \pi_t(s^{t+1}|s^t)[U_{c,t+1}(s^{t+1})(A_{t+1}(s^{t+1})F_{k,t} \\ +(1-\delta)[1+\tau_{x,t+1}(s^{t+1})]) + \phi_{k_{t+1}}])^{-1}\end{aligned} \tag{13}$$

### 3.2 Estimation

The stochastic process $\pi_t(s^t)$ and the event $s^t$ are unknown. As a result, to estimate the equilibrium allocation, some assumptions must be made. First:

$$k_o = x_0 \tag{14}$$

allowing us to obtain capital value at time 0. Given the realised data on $y_t$, $c_t$, $x_t$, $l_t$, and $g_t$, we can solve equations (10), (11), (12), but not (13), as it contains an expectation term over future realisations $\pi_t(s^{t+1}|s^t)$. Based on Chari et al. (2007a), expectations are predicted to behave according to a first-order Markov process:

$$\pi_t(s_t|s^{t-1}) = \pi_t(s_t|s_{t-1}) \tag{15}$$

meaning that the conditional probability of $s_t$ remains unchanged, regardless of whether we take into account all past events leading up to the current period or just the immediately preceding time. As such, the event $s_t$ can be utilised to make predictions for $s_{t+1}$. We also assume that future wedges are shaped by the realisation of past wedges. Furthermore, $s_t$ can be derived by using the wedges in period $t$. So, $s_t$ is mapped in a one-to-one relationship with the wedges:

$$s_t = [A_t, 1 - \tau_{l,t}, 1/[1 + \tau_{x,t}], g_t] \tag{16}$$

and follows a first-order autoregressive process:

$$s_{t+1} = P_0 + P s_t + \varepsilon_{t+1} \tag{17}$$

where $P_0$ represents the constants' vector, $P$ denotes the 4x4 matrix of coefficients, and $\varepsilon_{t+1}$ is the i.i.d. error term vector, which is normally distributed with a mean of zero. The positive semidefinite variance-covariance matrix of the error term is given by $V = QQ'$, where $Q$, the lower triangular matrix, has no interpretation in structural terms.

To estimate the wedges, we begin by determining the steady-state quantities. Next, the decision rules are computed by log-linearising the equilibrium conditions around the economy's steady state. The endogenous variables are then articulated as linear functions of the state variables $s_t$ and $k_t$, allowing for the construction of a state-space representation of the model. Data on the economic variables, along with the Kalman filter, are utilised to recursively obtain the innovations to the wedges. With that, we can derive the unknown parameters of the stochastic AR(1) process via a standard Maximum Likelihood Estimation. So, the four wedges are built using the estimated model combined with the data. Finally, to measure the relative significance of each type of distortion, we isolate the marginal effect associated with a given wedge or with a combination of wedges. A wedge, or a set of wedges, is subsequently fed back into the model as shocks, while the remaining ones are held at their steady-state levels.

# 4 Data Collection and Transformation

To conduct the BCA exercise, we utilise quarterly data for the Netherlands spanning from 1970:Q1 to 2022:Q4. This timeframe was determined based on the overlap of periods with available data at our data sources.

The data was obtained from the OECD databases. Gross domestic product, GDP deflator, gross capital formation, private final consumption expenditures, government final consumption expenditures, exports of goods and services, imports of goods and services, total employment, and hours worked per employee were drawn from the OECD Economic Outlook No 115. For durable goods, we took data from the Quarterly National Accounts. Moreover, the statistics on the population aged between 15 and 64 came from the OECD Employment and Labour Market Statistics database. At the same time, data on the tax on goods and services was collected from a corresponding indicator with the same name.

The last two variables are only available at annual frequency from 1970 to 2022. As such, we have transformed them to quarterly frequency through linear interpolation. For consumer durable goods, the data available is limited to the 1995:Q1 to 2022:Q4 period. To estimate the missing data, consumer durables expenditure is regressed on a constant, investment, and output in logarithmic form. The capital stock is then calculated using the perpetual inventory model.

Total hours worked corresponds to the product of total employment and hours worked per worker. The government consumption variable, $g_t$, encompasses not only government final consumption expenditures but also net exports. Chari et al. (2005) have mapped an open economy to a closed economy in which the government wedge captures the driving mechanism behind shocks in the global trade of goods and services.

Since it yields a service flow of consumption, the expenditure on durables is reallocated from consumption to investment. The corresponding service flow, $r_D$, and depreciation rate,

$\delta_D$, are added to consumption and output. They are assumed to be 4% and 25% annually, respectively (Brinca et al. 2016). The tax on goods and services is presumed to be levied on consumption. Therefore, tax revenue on goods and services related to the consumption of durables is deducted from investment, and the remainder is taken from private consumption. The total tax revenue on goods and services is then subtracted from output to ensure that the aggregate resource constraint is satisfied.

To derive the real *per capita* economic values, all variables are divided by the population aged 15 to 64 and deflated by the GDP deflator. In the end, we obtain four final variables: output *per capita*, hours worked *per capita*, investment *per capita*, and government consumption *per capita*. These will be inputted into the *BCAppIt! V1.000*, developed by Francesca Loria and Pedro Brinca, which will assist us in solving the BCA exercise. Note that private consumption *per capita* can be easily computed through the aggregate resource constraint (equation (7)). The economic variables are logged, detrended, and indexed to levels of 2019:Q4, as it corresponds to the last period prior to the coronavirus shock in the Dutch economy.

Figure 1: Fluctuations of the Economic Variables from 2019:Q4 to 2021:Q4

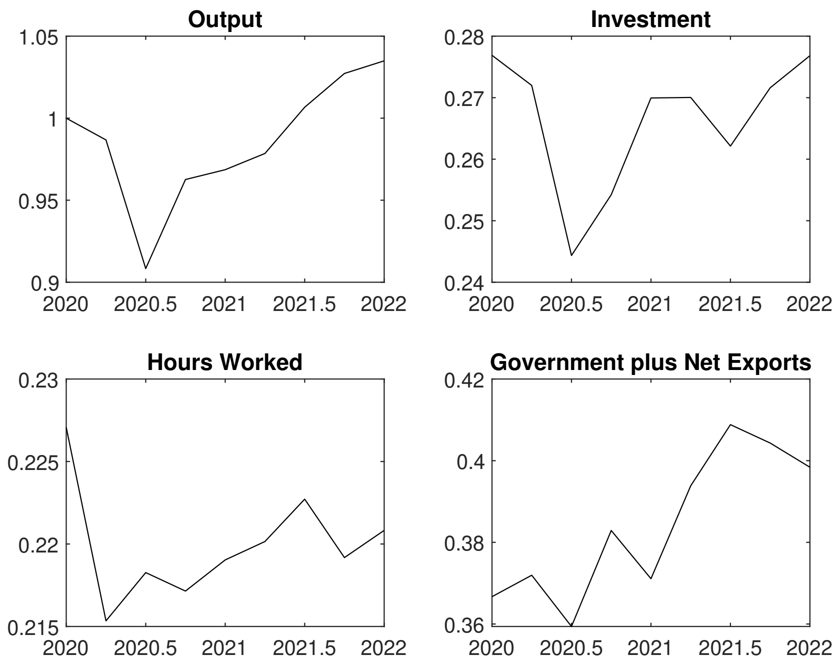


Figure 1 illustrates the movements of the four key macroeconomic variables during the period spanning from 2019:Q4 to 2021:Q4. Output *per capita* and investment *per capita* experienced similar paths during the coronavirus recession. Due to economic uncertainty, both variables suffered a moderate drop in the first quarter of 2020, followed by a sharp contraction in the subsequent quarter. Compared to the 2008 financial crisis, the fall in and out of the crisis was more rapid, taking nearly a year to rebound. However, the recovery in investment proved to be less stable than that of output, with investment reaching pre-pandemic levels at a later date.

Regarding hours worked *per capita*, a sharp decline in the first quarter of 2020 was observed as firms started to close, with a slight increase in the next quarter. The introduction of a wage subsidy scheme prevented a further rise in the unemployment rate. Nevertheless, hours worked *per capita* have not yet returned to the pre-crisis state. In contrast, government consumption *per capita* behaved differently from the previous variables. Despite the fall in net exports driven by the disruption in supply chains and demand shortages, government expenditure increased in an effort to mitigate the economic fallout. This rise effectively offset the deterioration in the trade balance. Consequently, this variable recorded higher values than those registered initially.

Table 1: Model Parameters

| $\beta$ | $\delta$ | $\psi$ | $\alpha$ | $r_D$ | $\delta_D$ | $\gamma_n$ | $\gamma$ | $a$ | $b$ |
|---|---|---|---|---|---|---|---|---|---|
| 0.9930 | 0.0118 | 2.24 | 0.35 | 0.01 | 0.0694 | 0.0016 | 0.0037 | 14.6199 | 0.0171 |

Table 1 describes the exogenous parameters of the model. Following Chari et al. (2007a), the discount factor, $\beta$, is set at 0.993, the depreciation rate, $\delta$, at 0.0118—corresponding to an annualised rate of 5%—the time allocation, $\psi$, at 2.24, and the capital share in the production function, $\alpha$, at 0.35. As mentioned earlier, the service flow of consumption for durable goods, $r_D$, and its respective depreciation rate, $\delta_D$, are assumed to be 4% and 25% annually (Brinca et al. 2016). The average growth rate of population, $\gamma_n$, and the growth rate of labour-augmenting technology, $\gamma$, are country-specific, with values of 0.0016 and 0.0037, respectively. In line with

Bernanke, Gertler, and Gilchrist (1999), the marginal capital adjustment costs, $a$, is calibrated at 14.6199, ensuring that the elasticity, $\eta = ab$, regarding the investment-capital ratio, $\rho = \frac{1}{1-\phi(.)}$, equals 0.25. The steady-state value of the investment–capital ratio, $b$, is set at 0.0171.

# 5 Findings

Figure 2: Parameters' Matrixes of the Stochastic AR(1) Process.

$$P = \begin{bmatrix} 1.0597 & -0.0003 & -0.0374 & -0.0037 \\ 0.1904 & 0.9990 & -0.0525 & -0.0110 \\ 0.1666 & -0.0060 & 0.8913 & -0.0088 \\ -0.2462 & 0.0915 & 0.1617 & 0.9942 \end{bmatrix} \qquad Q = \begin{bmatrix} 0.0206 & 0.0063 & 0.0547 & 0.0194 \\ 0.0063 & 0.0288 & -0.0069 & 0.0993 \\ 0.0547 & -0.0069 & 0.0025 & -0.0154 \\ 0.0194 & 0.0993 & -0.0154 & 0.0238 \end{bmatrix}$$

$$P_0 = \begin{bmatrix} 0.0074 & -0.0066 & 0.0264 & -0.0971 \end{bmatrix} \qquad \bar{s}_t = \begin{bmatrix} 0.1140 & 0.4959 & 0.4619 & -0.8759 \end{bmatrix}$$

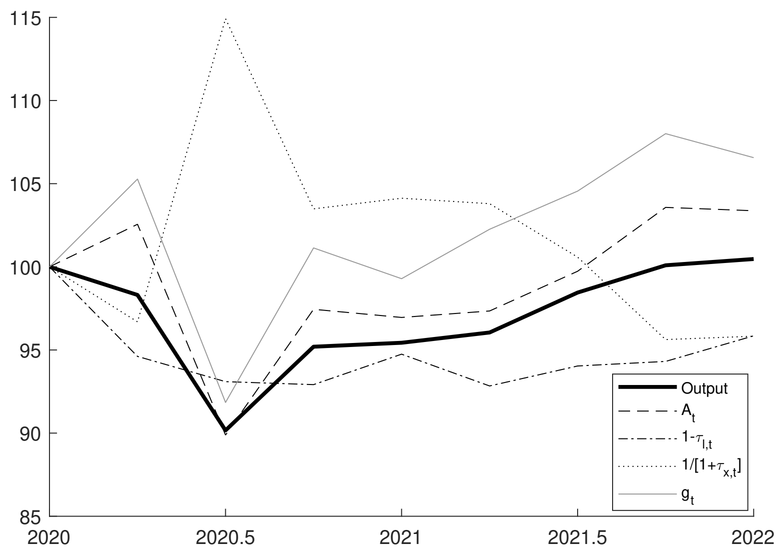
To derive $P_0$, $P$, and $Q$, the first-order autoregressive process, described in equation (17), is solved through a standard Maximum Likelihood Estimation. The parameters' matrixes are presented in Figure 2. The remainder of the chapter is divided into two sections. The first section describes the results obtained from applying the BCA framework to the Dutch economy during the coronavirus outbreak. The second part discusses the channels through which the pandemic might have impacted output, offering potential interpretations for the observed wedges.

## 5.1 Estimated Wedges and Simulations

By using actual data and the estimated model, we are able to estimate the realised wedges. The four time-varying wedges, normalised to one in 2019:Q4, revealed distinct patterns (see Figure 6 in Appendix). The efficiency and the government wedges display similar trajectories; however, the latter consistently shows higher values, with nearly all its values exceeding one. The government wedge also fluctuates more frequently as its historical standard deviation is the farthest from that of actual output. Looking at the historical properties of the wedges, the efficiency wedge presents the strongest correlation with output (0.82), while the government wedge holds little to no correlation (0.05).

Additionally, the labour wedge, like the efficiency wedge, experienced a substantial downturn during the first half of 2020, although this contraction occurred one quarter earlier than that observed in the efficiency wedge. Despite this, while the efficiency wedge returned to pre-pandemic values by the end of 2021, the labour wedge remained relatively stable but below its initial levels. In contrast, the investment wedge exhibits an opposite pattern, consistent with the historical negative correlation with output (-0.77). This wedge rose in the first half of 2020, subsequently decreasing as the economy started to recover.

Figure 3: Output and Simulated Output with One Wedge from 2019:Q4 to 2021:Q4




To evaluate the relative significance of each wedge in explaining the distortions in the economic variables, the time-varying wedges are reintroduced into the prototype economy, either individually or in groups, while the others are held at their steady-state levels. Figure 3 presents the actual data and the four 'one wedge economies' concerning the Dutch output for the period comprised between 2019:Q4 and 2021:Q4.

The economy with the efficiency wedge seems to play a crucial role in explaining output movements during the downturn and recovery phases. Even though the signs of the output variation differed in the first quarter of 2020, we notice that both simulated and actual output followed a similar contraction path in the subsequent quarter, as fiscal support harmed the efficient use and allocation of factor inputs. This distortion is captured by the efficiency wedge. Furthermore, the predicted output also accurately mirrors the slow recovery, with its values hovering slightly above the observed ones. Between 2020:Q2 and 2020:Q3, the model predicts an increase in output of 8.4%, while actual data reports a smaller rise of 5.6%.

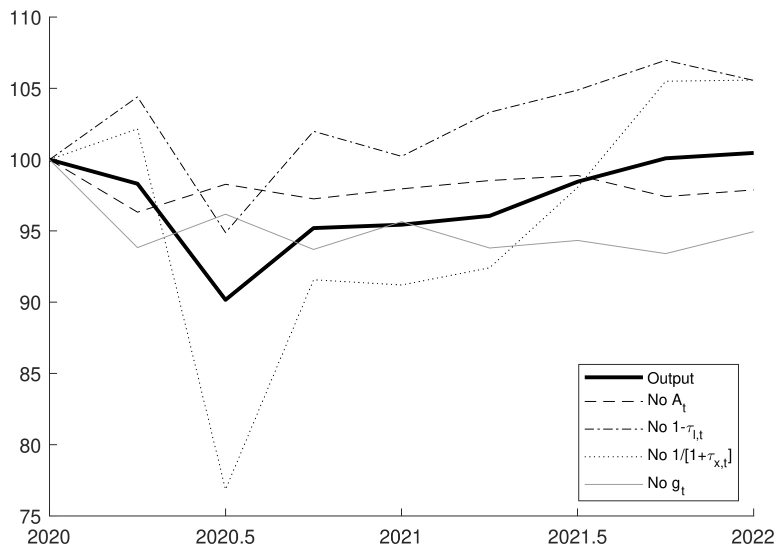
Similarly, the government wedge might be considered an important factor in accounting for variations in output. The model with the government wedge resembles the economy mentioned above; however, the latter presents more optimistic values than those recorded in the actual data. This model predicts output to fall by 8.2%, whereas actual output shrank by 9.8% in the first half of 2024. Additionally, the recovery was more rapid in the government wedge model, where output registered an increase of 10.1% from 2020:Q2 to 2020:Q3.

In terms of the labour wedge, the model appears to track output fluctuations closely with the actual data. Nevertheless, an examination of Figure 3 reveals that the simulated and observed data share the same sign in a low percentage of instances. Moreover, the fall in the predicted economy occurs a quarter earlier, decreasing by 5.4% in the first quarter, while actual output drops only by 1.7%. Following this, the model without the labour wedge suggests a gradual continued contraction in output, with a slight recovery during the fourth quarter of 2020, but never returning to pre-pandemic levels.

On a different note, the investment wedge does not adequately explain the observed distortions in output. It not only seems to have a weak effect on output variation but also takes an entirely different direction during the coronavirus pandemic. Specifically, the investment wedge results in an approximate 14.9% rise in output during the first half of 2020, in contrast to the contraction reflected in actual data. These developments illustrate how certain fiscal and monetary measures mitigated the decline in investment, distorting the intertemporal Euler equation.

Figure 4 illustrates the observed output alongside the corresponding four 'one wedge off

Figure 4: Output and Simulated Output without One Wedge from 2019:Q4 to 2021:Q4




economies'. None of the models seem to accurately capture the dynamics of the actual economy. The model without the efficiency wedge fails to replicate the output downturn experienced during the coronavirus outbreak. In fact, it predicts an increase in this period. Nevertheless, it appears to explain the economic recovery phase quite well. The model that excludes the government wedge shows an identical pattern. In the meantime, by fixing the investment wedge at its constant levels, the model predicts a more pronounced decline of 23.1% in output during the first half of 2020, followed by a quicker recovery in 2021; however, it closely tracks the trajectory of the actual output data. Similarly, in the absence of the labour wedge, the model mirrors the actual output trend but it tends to be overly optimistic, projecting a contraction of only 5.1% in the first half of 2020, compared to the actual output decline of 9.8%.

The BCA literature has introduced a few indicators, such as the mean square error, the success ratio, and Theil's U, to quantify the relative significance of each wedge to the variance in the variable of interest. Brinca et al. (2016) proposed a coherent $\phi$-statistic for evaluating each model. The measure of the importance of the wedges assesses how closely a specific wedge aligns with the actual movements of the variable in focus. It can be computed as follows:

$$\phi_i^y = \frac{1/\sum_t (y_t - y_{it})^2}{\sum_j \sum_t (1/(y_t - y_{jt})^2)} \tag{18}$$

where $y_t$ corresponds to the detrended output and $y_{it}$ denotes the output component attributable to the wedge. This quantitative measurement operates on a scale from 0 to 1, where values approaching 1 indicate a stronger model. Since all wedges contribute to the overall movement in the data, the cumulative sum of this statistic across the four wedges equals one.

Table 2: Contribution of Each Wedge in the Variation of Output from 2019:Q4 to 2021:Q4

| **Statistic** | $\phi_A^y$ | $\phi_l^y$ | $\phi_x^y$ | $\phi_g^y$ |
|---|---|---|---|---|
| One Wedge Economies | 0.6191 | 0.2405 | 0.0356 | 0.1048 |
| One Wedge Off Economies | 0.4447 | 0.1445 | 0.1520 | 0.2588 |

As shown in Table 2, the efficiency wedge is the primary factor contributing to output distortions, with the $\phi$-statistic reaching 62%. In the meantime, the labour wedge accounts for a small yet non-negligible portion of the observed fluctuations, responsible for 24% of the total movement in output. In contrast, both the investment and government wedges have a null impact on output variability. Furthermore, we observed that the model without the efficiency wedge yields the highest $\phi$-statistic between 'one wedge off economies'; however, this statistic only captures 44% of total movement, and the success ratio stands at a modest value of 0.7 (see Figure 8 in Appendix). Ultimately, similar to the 2008 financial crisis, researchers should focus on distortions reflected in the efficiency wedge when developing quantitative models aimed at replicating the effects in the Dutch output caused by the coronavirus outbreak.

We have also computed similar statistics for hours worked and investment. Table 3 displays the contributions of each wedge to the variations in these two variables. For hours worked, the model without the efficiency wedge presents the best performance among all simulations. In contrast, the labour wedge accounts for most of the movements in investment, followed by the efficiency wedge. The investment and government wedges have a minor role in this context.

Table 3: Contribution of Each Wedge in the Variation of Hours Worked and Investment from 2019:Q4 to 2021:Q4

| **Statistic** | $\phi_A$ | $\phi_l$ | $\phi_x$ | $\phi_g$ |
|---|---|---|---|---|
| Hours Worked | | | | |
| One Wedge Economies | 0.6052 | 0.2513 | 0.0658 | 0.0777 |
| One Wedge Off Economies | 0.9847 | 0.0039 | 0.0039 | 0.0075 |
| Investment | | | | |
| One Wedge Economies | 0.4325 | 0.4344 | 0.0130 | 0.1202 |
| One Wedge Off Economies | 0.3021 | 0.2818 | 0.1962 | 0.2199 |

### 5.2 Discussion

Given the widespread uncertainty, the coronavirus epidemic brought unprecedented challenges all over the world. Not only did it have health-related implications, but it also caused the global economy to shut down, with disruptions in the supply chain threatening the productivity gained through globalisation. As a major trading nation, the Netherlands faced a decline in its trade balance, reflecting the economy's high vulnerability to fluctuations in external markets.

After a period of steady growth, the Dutch economy experienced a severe downturn, driven by the deterioration of international markets and the impact of containment measures. Both demand and supply for goods and services were drastically affected. Due to reduced consumer confidence, households adjusted their spending habits by cutting expenditure on non-essential goods and services, while increasing 'precautionary savings'. In terms of the supply side, firms had their production operations limited, with the transportation and hospitality sectors facing the most pronounced effects (Hoekman et al. 2020).

Further economic damage was prevented through strong economic infrastructures, such as the high level of digitalisation prior to the outbreak and the knowledge-intensive nature of economic activities. Mild health interventions and effective fiscal support also played a crucial role. The GDP fallout in 2020 would have been 0.6 percentage points greater had no stimulus packages been implemented (Adema et al. 2021). In accordance with the International Monetary Fund, the first two stimulus packages, designed to protect the resilience of the business community by addressing liquidity constraints and reducing the probability of job losses (Pál and Lalinsky 2021), amounted to 35.3 billion euros. This exceptional fiscal response was made possible thanks to the temporary relaxation of the Stability and Growth Pact (SGP) rules, which enabled the Netherlands to surpass the usual fiscal limits as public spending ramped up to support the economy.

In terms of the labour market, conditions deteriorated due to the virus's rapid spread, business closures, and economic uncertainty. Firms subject to operational restrictions and lower consumer demand became less willing to hire at a specific hourly rate. Labour demand then faced a slowdown, with the unemployment rate rising slightly, reaching its peak of 5.5% in August 2020. Flexible payroll jobs were the first to disappear, disproportionately affecting younger individuals who left the workforce without any compensation (Dullemen and Bruijn 2021).

Successful job retention schemes softened the shock in labour demand. The *Noodmaatregel Overbrugging voor behoud van Werkgelegenheid* (NOW) ensured the preservation of employment and disposable income by subsidising firms' wage bills, regardless of their employees' actual working hours. In consequence, working hours underwent a contraction. Individuals with lower socioeconomic status suffered a steeper decrease given the pandemic-specific job characteristics such as telecommutability and essential worker status (Zimpelmann et al. 2021). However, unemployment was kept low, hiding the high flexible work unemployment numbers.

Regarding the labour supply, vulnerable and risk-averse workers withdraw from the workforce (Meekes, Hassink, and Kalb 2023), willing to accept long-term consequences to avoid health-related risks (Chorus, Sandorf, and Mouter 2020). High-contact sectors with a small share of telecommuting experienced the most significant negative impacts on labour supply (Brinca, Duarte, and Faria-e-Castro 2021; DNB 2020). Furthermore, the closure of schools and childcare facilities further constrained labour supply, particularly affecting single parents and non-essential workers with children who lacked access to emergency childcare policies

(Meekes et al. 2022). Ultimately, the effects on labour supply were overshadowed by the effects on labour demand (Meekes et al. 2022; DNB 2020).

Since the job retention scheme (NOW) averted a significant drop in labour, for the production function (equation (6)) to be satisfied, capital, $k_t$, and/or the efficiency wedge, $A_t$, must have adjusted to accompany the decline in output, assuming wages and rental rates are sticky.

Investment experienced a decline as entrepreneurs' trust in the economy shrank, prompted by high levels of uncertainty and risk aversion among investors. Many firms began to prioritise liquidity and postponed capital expenditures. Nevertheless, financial support mitigated further declines, by facilitating firms' access to liquidity to cover working capital shortfalls. Low interest rates and an expanded bond-buying program contributed to maintaining low financing costs for Dutch companies. Moreover, credit deferral programs and moratoriums eased the financial burden on households and firms, distorting the intertemporal Euler equation (equation (2)) between present and future consumption. Liquidity support, including reimbursement of fixed costs programs and credit guarantee schemes, also enabled businesses to sustain their investment and capital levels. As such, the investment wedge positively influenced the state of the economy, resulting only in a slight drop in capital growth.

On the other hand, the efficiency wedge, one of the main determinants of economic growth, faced a significant negative impact at the onset of the outbreak, reflecting the substantial fall in labour productivity and Total Factor Productivity in 2020. The effects were heterogeneous across different sectors, as lockdown measures affected predominantly high-contact industries (Meijerink, Bettendorf, and Freeman 2021). In 2020, productivity growth decelerated by -3.1% in the services sector, while the manufacturing sector only saw a decrease of -1.9%.

The implementation of stimulus packages played a crucial role in keeping businesses running, with the number of bankruptcies at a historically low level. The exit rate of supported firms was lower than that observed for non-supported firms. Although business resilience was successfully strengthened, the easily accessible stimulus packages distorted the process of creative destruction, at least in an initial phase, by keeping alive a high number of low-productivity firms (Freeman, Bettendorf, and Adema 2021). A considerable share of the government support schemes was being inefficiently allocated to these low-productivity firms (Creemers et al. 2022), as the recession hit these firms more heavily.

Furthermore, the wage subsidy scheme (NOW) harmed productivity and resource reallocation due to labour hoarding (D'Adamo, Bianchi, and Granelli 2021). Firms were able to sustain their workforce and capital levels, despite the limited production and low profitability. Therefore, human capital was prevented from moving to more productive activity. Even though financial systems enable agents to allocate resources to their most efficient uses, this dynamic is captured by the efficiency wedge instead of the investment wedge. In terms of capital, part became obsolete, reducing capacity utilisation and labour productivity (Meijerink et al. 2021).

After the downturn in the first half of 2020, the Dutch economy recovered strongly on a powerful V-shape as businesses adapted to the new conditions, containment measures started to ease, and international trade balance and demand for goods and services improved. The productivity growth followed this trend (Figure 3), driven by the increase in Total Factor Productivity, particularly within the healthcare and manufacturing sectors (Bettendorf and Freeman 2023). Although the degree of digitalisation and teleworking was already high prior to the pandemic, these developments further spurred innovation and digitalisation, fostering structural changes that could enhance long-term productivity. Nevertheless, it was not until late 2021 that the economy returned to pre-crisis levels, as new virus waves hit the economy.

## 6 Final Remarks

The coronavirus recession was not a market failure. Given the non-economic nature of the shock, researchers have faced significant challenges when attempting to model this period's economic movements. In response, Chari et al. (2007) developed a framework that helps identify theories with greater quantitative relevance in explaining business cycle fluctuations. It is important to mention that the so-called BCA framework does not pinpoint the direct source of the shock, but instead focuses on the transmission mechanisms.

Our paper aims to conduct a BCA exercise to assess the relevant distortions through which the pandemic has affected the Dutch economy. Similar to the 2008 financial crisis (Brinca et al. 2016), the efficiency wedge is the primary factor in accounting for output dynamics, contributing 62% to the total output variance. Financial frictions may have undermined the efficiency wedge, as fiscal measures harmed the efficient utilisation and allocation of factor inputs. Despite successfully improving business resilience, financial support kept unviable firms afloat, distorting the creative destruction process. Furthermore, the wage subsidy scheme (NOW) allowed firms to retain their workforce, even in instances of limited production, preventing also the movement of workers to higher-productivity firms.

Following the contribution of the efficiency wedge, the labour wedge is responsible for 24% of the total movement in output, a small yet non-negligible portion of the observed fluctuations. The government and investment wedges show minimal impact. Regarding hours worked, an economy without the efficiency wedge most accurately reflects the behaviour of hours worked. In contrast, the labour wedge plays a primary role in explaining variations in investment.

Researchers interested in developing a quantitative model to replicate the business cycle distortions during the coronavirus outbreak are encouraged to explore models featuring productivity distortions. Some potential literature that can assist with this task is found in Lagos (2006). The author puts forward an aggregative model of total factor productivity, which allows them to examine how labour-market policies influence total factor productivity. Consequently, researchers are also able to evaluate the impact on output driven by the misallocation of factor inputs, such as labour and capital.

## References

Abramovitz, Moses. 1956. "Resource and output trends in the United States since 1870." In *Resource and output trends in the United States since 1870,* 1–23. NBER.

Adema, Yvonne, Leon Bettendorf, Claudia Deijl, Daan Freeman, Loes Verstegen, and Eva van der Wal. 2021. *Economische analyse steunpakket 2020.* Technical report. CPB Netherlands Bureau for Economic Policy Analysis.

Bernanke, Ben, Mark Gertler, and Simon Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework." *Handbook of Macroeconomics/Elsevier* 1:1341–1393.

Bettendorf, Leon, and Daan Freeman. 2023. *National Productivity Board 2022 Annual Report.* Technical report. National Productivity Board.

Bollino, Carlo Andrea. 2023. "The human life vs economic loss dilemma: Relation between death rate and the output rate in Europe during the Covid 19 pandemic." *Journal of Policy Modeling* 45 (2): 377–387.

Bridji, Slim. 2013. "The French Great Depression: A business cycle accounting analysis." *Explorations in Economic History* 50 (3): 427–445.

Brinca, Pedro, Varadarajan V Chari, Patrick J Kehoe, and Ellen McGrattan. 2016. "Accounting for business cycles." In *Handbook of macroeconomics,* 2:1013–1063. Elsevier.

Brinca, Pedro, João Ricardo Costa Filho, and Francesca Loria. 2024. "Business Cycle Accounting: what have we learned so far?" *Journal of Economic Surveys* 38 (4): 1276–1316.

Brinca, Pedro, Joao B Duarte, and Miguel Faria-e-Castro. 2021. "Measuring labor supply and demand shocks during COVID-19." *European Economic Review* 139:103901.

Chari, Varadarajan V, Patrick J Kehoe, and Ellen R McGrattan. 2002. "Accounting for the great depression." *American Economic Review* 92 (2): 22–27.

———. 2005. "Sudden stops and output drops." *American Economic Review* 95 (2): 381–387.

———. 2007a. "Business cycle accounting." *Econometrica* 75 (3): 781–836.

———. 2007b. "Comparing alternative representations and alternative methodologies in business cycle accounting." *Available at SSRN 1162859.*

Chorus, Caspar, Erlend Dancke Sandorf, and Niek Mouter. 2020. "Diabolical dilemmas of COVID-19: An empirical study into Dutch society's trade-offs between health impacts and other effects of the lockdown." *Plos one* 15 (9): e0238683.

Christiano, Lawrence J, and Joshua Mark Davis. 2006. "Two flaws in business cycle dating."

Christiano, Lawrence J, and Martin Eichenbaum. 1992. "Current real-business-cycle theories and aggregate labor-market fluctuations." *The American Economic Review,* 430–450.

Christiano, Lawrence J, Christopher Gust, and Jorge Roldos. 2004. "Monetary policy in a financial crisis." *Journal of Economic theory* 119 (1): 64–103.

Creemers, Sarah, Michael Polder, Rik van Roekel, and Mark Vancauteren. 2022. *Covid-19 Financial Support and Firm's Productivity: Evidence from the Netherlands.* Growth Welfare Innovation Productivity (GROWINPRO).

D'Adamo, Gaetano, Maria Bianchi, and Lucia Granelli. 2021. *Digitalisation and beyond: The COVID-19 pandemic and productivity growth in G20 countries.* Technical report. Directorate General Economic and Financial Affairs (DG ECFIN), European ...

De Haas, Mathijs, Roel Faber, and Marije Hamersma. 2020. "How COVID-19 and the Dutch 'intelligent lockdown'change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands." *Transportation research interdisciplinary perspectives* 6:100150.

Dullemen, Caroline van, and Jeanne de Bruijn. 2021. "The Dutch Approach to COVID-19." *PRISM* 9 (4): 106–117.

Dutch National Bank. 2020. "Supply and Demand Shocks Due to the Coronavirus Pandemic Contribute Equally to Contraction in Production." https://www.dnb.nl/en/general-news/news-2020/supply-and-demand-shocks-due-to-the-coronavirus-pandemic-contribute-equally-to-contraction-in-production/.

Freeman, Daan, Leon Bettendorf, and Yvonne Adema. 2021. "Covid-19 Support Distorted the Process of Creative Destruction in the Netherlands." https://voxeu.org/article/covid-19-support-disrupted-creative-destruction-netherlands.

Gerth, Florian, and Keisuke Otsu. 2018. "The post-crisis slump in Europe: a business cycle accounting analysis." *The BE Journal of Macroeconomics* 18 (1): 20160189.

Hale, Thomas, Noam Angrist, Rafael Goldszmidt, Beatriz Kira, Anna Petherick, Toby Phillips, Samuel Webster, et al. 2021. "A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker)." *Nature Human Behaviour,* https://doi.org/10.1038/s41562-021-01079-8.

Hevia, Constantino. 2014. "Emerging market fluctuations: What makes the difference?" *Journal of International Economics* 94 (1): 33–49.

Hoekman, Lieke Michaela, Marlou Marriet Vera Smits, and Xander Koolman. 2020. "The Dutch COVID-19 approach: regional differences in a small country." *Health Policy and Technology* 9 (4): 613–622.

International Monetary Fund. 2021. "Policy Responses to COVID-19." https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19#N.

Iskrev, Nikolay. 2013. "Business cycle accounting for Portugal." *Economic Bulletin and Financial Stability Report Articles.*

Kydland, Finn E, and Edward C Prescott. 1982. "Time to build and aggregate fluctuations." *Econometrica: Journal of the Econometric Society,* 1345–1370.

Lagos, Ricardo. 2006. "A model of TFP." *The Review of Economic Studies* 73 (4): 983–1007.

Lama, Ruy. 2011. "Accounting for output drops in Latin America." *Review of Economic Dynamics* 14 (2): 295–316.

López, Jesús Rodríguez, and Mario Solís García. 2016. "Accounting for Spanish business cycles." *Macroeconomic Dynamics* 20 (3): 685–714.

Meekes, Jordy, Wolter HJ Hassink, and Guyonne Kalb. 2023. "Essential work and emergency childcare: Identifying gender differences in COVID-19 effects on labour demand and supply." *Oxford Economic Papers* 75 (2): 393–417.

Meijerink, Gerdien, Leon Bettendorf, and Daan Freeman. 2021. *National Productivity Board 2021 Annual Report.* Technical report. National Productivity Board.

Mendoza, Enrique G. 2010. "Sudden stops, financial crises, and leverage." *American Economic Review* 100 (5): 1941–1966.

Organisation for Economic Co-operation and Development. 2024a. *Labour Force Statistics: Historical Population Data.* OECD Employment and Labour Market Statistics (database). Accessed: 2024-08-17. https://doi.org/10.1787/4cf3d106-en.

———. 2024b. *OECD Economic Outlook No 115 (Edition 2024/1).* OECD Economic Outlook: Statistics and Projections (database). Accessed: 2024-08-17. https://doi.org/10.1787/65f9bbcb-en.

———. 2024c. *Quarterly National Accounts.* OECD National Accounts Statistics (database). Accessed: 2024-08-17. https://doi.org/10.1787/data-00017-en.

———. 2024d. *Tax on Goods and Services (indicator).* Accessed: 2024-08-17. https://doi.org/10.1787/40b85101-en.

Otsu, Keisuke. 2010a. "A neoclassical analysis of the Asian crisis: Business cycle accounting for a small open economy." *The BE Journal of Macroeconomics* 10 (1).

———. 2010b. *International business cycle accounting.* Technical report. School of Economics Discussion Papers.

Pál, Rozália, and Tibor Lalinsky. 2021. *EIB Working Paper 2021/06-Efficiency and effectiveness of the COVID-19 government support: Evidence from firm-level data.* European Investment Bank.

Solow, Robert M. 1957. "Technical change and the aggregate production function." *The review of Economics and Statistics* 39 (3): 312–320.

Šustek, Roman. 2011. "Monetary business cycle accounting." *Review of Economic Dynamics* 14 (4): 592–612.

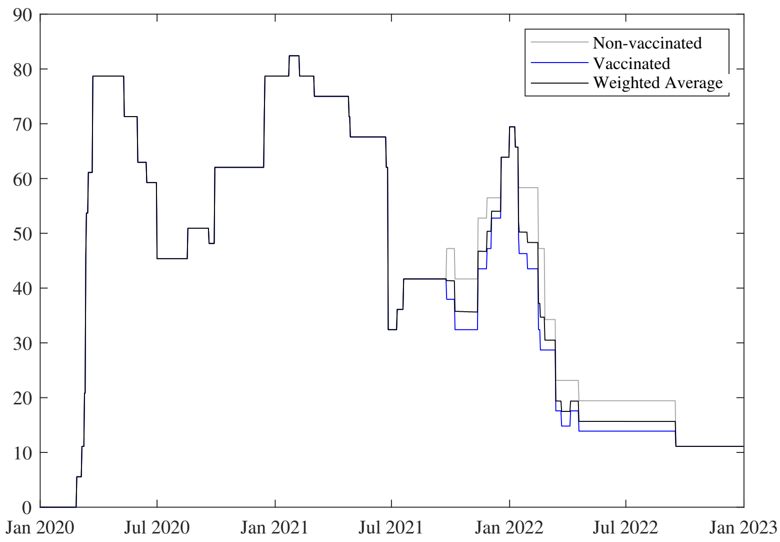
World Bank. 2024. "GDP Growth (Annual %) - Netherlands." Accessed: 2024-08-17. https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=NL.

World Health Organization. *WHO Coronavirus Disease (COVID-19) Dashboard.* https://covid19.who.int.

Zimpelmann, Christian, Hans-Martin von Gaudecker, Radost Holler, Lena Janys, and Bettina Siflinger. 2021. "Hours and income dynamics during the Covid-19 pandemic: The case of the Netherlands." *Labour Economics* 73:102055.

# 7 Appendix

Figure 5: Stringency Index for the Netherlands




**Note:** The Stringency Index is a composite metric, which combines nine distinct response indicators, including but not limited to school closures, workplace closures, and travel restrictions. It is quantitatively scaled between 0 and 100, with 100 corresponding to the strictest level.
**Source**: Blavatnik School of Government, University of Oxford (2023)

Figure 6: Data and Measured Wedges from 2019:Q4 to 2021:Q4

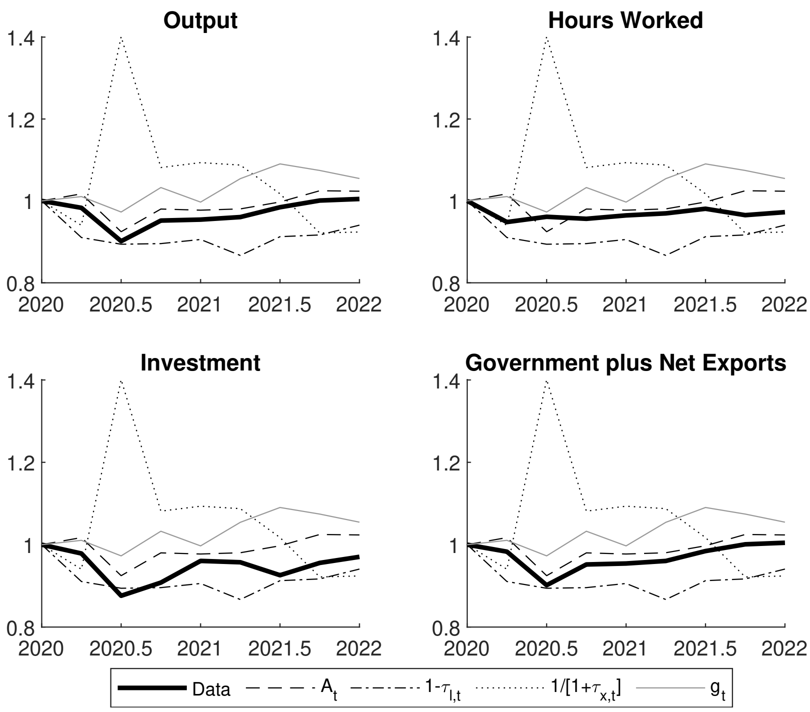


Table 4: Wedges' Properties in Relation with Output for the Entire Sample

| **Wedges** | **Rel. Std.** | **Cross Correlation of Wedge with Output at Lag k=** | | | | |
|---|---|---|---|---|---|---|
| | | -2 | -1 | 0 | 1 | 2 |
| Efficiency | 0.8947 | 0.4011 | 0.4787 | 0.8182 | 0.3872 | 0.1861 |
| Labour | 1.5373 | 0.1135 | 0.2990 | 0.2515 | 0.4155 | 0.4018 |
| Investment | 2.6559 | -0.3467 | -0.4059 | -0.7682 | -0.3261 | -0.1393 |
| Government | 3.1122 | 0.0257 | -0.0001 | 0.0483 | -0.0689 | -0.0620 |

Table 5: Wedges' Properties in Relation with Hours Worked for the Entire Sample

| **Wedges** | **Rel. Std.** | **Cross Correlation of Wedge with Hours at Lag k=** | | | | |
|---|---|---|---|---|---|---|
| | | -2 | -1 | 0 | 1 | 2 |
| Efficiency | 1.1766 | 0.2576 | 0.1853 | -0.0150 | 0.0443 | -0.1078 |
| Labour | 2.0218 | 0.4174 | 0.5205 | 0.6901 | 0.5647 | 0.4198 |
| Investment | 3.4930 | -0.2272 | -0.1928 | -0.0364 | -0.1223 | 0.1263 |
| Government | 4.0930 | -0.0804 | -0.0679 | -0.0522 | -0.0357 | -0.0874 |

Table 6: Wedges' Properties in Relation with Investment for the Entire Sample

| **Wedges** | **Rel. Std.** | **Cross Correlation of Wedge with Investment at Lag k=** | | | | |
|---|---|---|---|---|---|---|
| | | -2 | -1 | 0 | 1 | 2 |
| Efficiency | 0.1886 | 0.2113 | 0.2969 | 0.3893 | 0.1485 | 0.0462 |
| Labour | 0.3240 | 0.0410 | 0.1054 | 0.0233 | 0.2013 | 0.2157 |
| Investment | 0.5598 | -0.1319 | -0.2159 | -0.3410 | -0.0844 | -0.0143 |
| Government | 0.6559 | -0.0068 | 0.0880 | -0.7996 | 0.0504 | -0.0666 |

Table 7: Wedges' Properties in Relation with Government Variable for the Entire Sample

| **Wedges** | **Rel. Std.** | **Cross Correlation of Wedge with G+NX at Lag k=** | | | | |
|---|---|---|---|---|---|---|
| | | -2 | -1 | 0 | 1 | 2 |
| Efficiency | 0.2875 | -0.0446 | -0.833 | 0.0646 | 0.0459 | 0.0809 |
| Labour | 0.4940 | -0.0613 | -0.0530 | -0.1424 | -0.0841 | -0.0993 |
| Investment | 0.8534 | 0.0184 | 0.0730 | -0.0236 | -0.0661 | -0.0868 |
| Government | 1 | 0.0453 | -0.0818 | 1 | -0.0818 | 0.453 |

Figure 7: Hours Worked and Simulated Hours Worked with One Wedge from 2019:Q4 to 2021:Q4

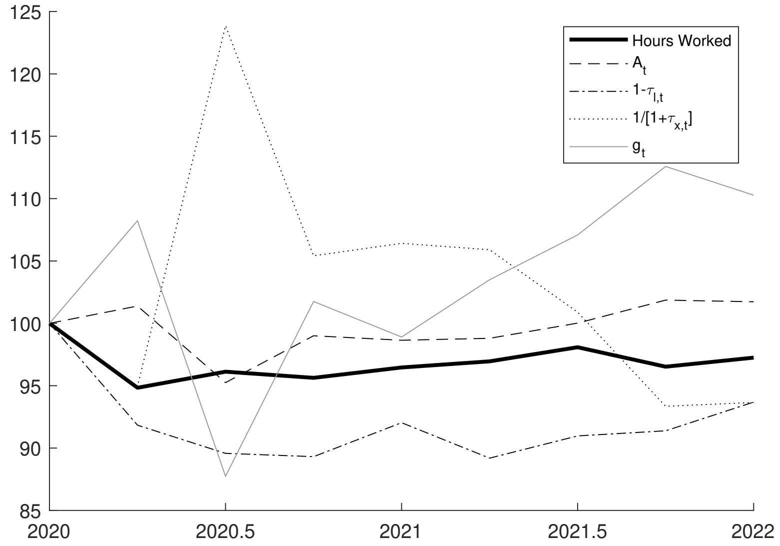



Figure 8: Hours Worked and Simulated Hours Worked without One Wedge from 2019:Q4 to 2021:Q4

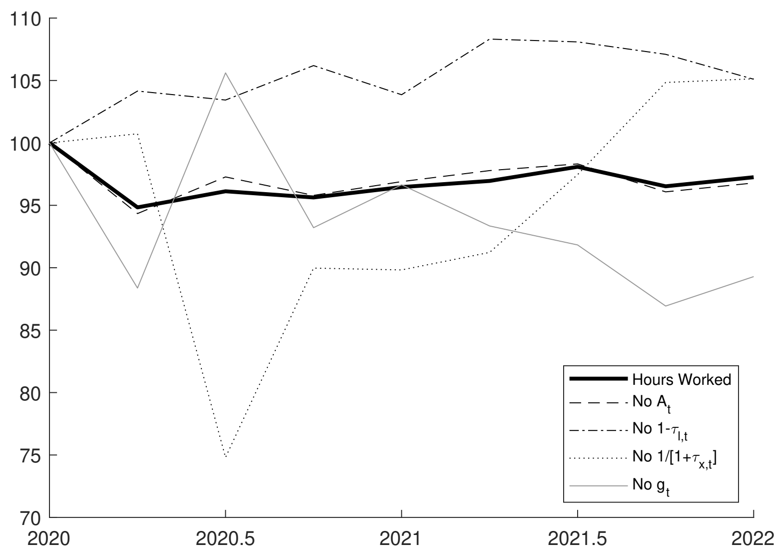


Figure 9: Investment and Simulated Investment with One Wedge from 2019:Q4 to 2021:Q4

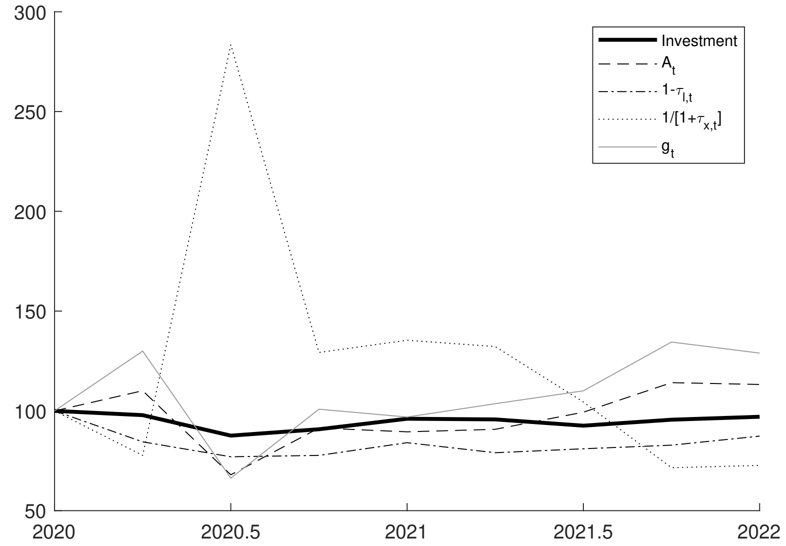



Figure 10: Investment and Simulated Investment without One Wedge from 2019:Q4 to 2021:Q4

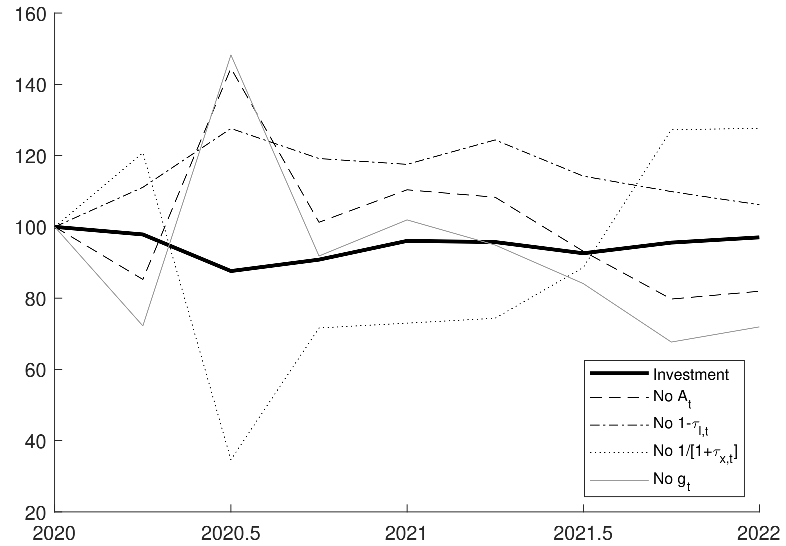


Table 8: Performance Measure of Each Wedge in Explaining the Variation of Output, Hours Worked and Investment from 2019:Q4 to 2021:Q4

| **Statistic** | **Efficiency** | **Labour** | **Investment** | **Government** |
|---|---|---|---|---|
| One Wedge Economies (Output) | | | | |
| Success Ratio | 0.9000 | 0.7000 | 0.2000 | 0.6000 |
| RMSE | 2.2384 | 3.5917 | 9.3366 | 5.4392 |
| $\phi_i^y$ | 0.6191 | 0.2405 | 0.0356 | 0.1048 |
| One Wedge Off Economies (Output) | | | | |
| Success Ratio | 0.7000 | 0.5000 | 0.9000 | 0.7000 |
| RMSE | 3.1860 | 5.5884 | 5.4490 | 4.1760 |
| $\phi_i^y$ | 0.4447 | 0.1445 | 0.1520 | 0.2588 |
| One Wedge Economies (Hours Worked) | | | | |
| Success Ratio | 0.5000 | 1 | 0.5000 | 0.3000 |
| RMSE | 3.4263 | 5.3164 | 10.3898 | 9.5630 |
| $\phi_i^l$ | 0.6052 | 0.2513 | 0.0658 | 0.0777 |
| One Wedge Off Economies (Hours Worked) | | | | |
| Success Ratio | 1 | 0.1000 | 0.6000 | 0.9000 |
| RMSE | 0.5429 | 8.6549 | 8.6182 | 6.2152 |
| $\phi_i^l$ | 0.9847 | 0.0039 | 0.0039 | 0.0075 |
| One Wedge Economies (Investment) | | | | |
| Success Ratio | 0.6000 | 1 | 0.5000 | 0.3000 |
| RMSE | 11.5698 | 11.5444 | 66.73 | 21.9489 |
| $\phi_i^x$ | 0.4325 | 0.4344 | 0.0130 | 0.1202 |
| One Wedge Off Economies (Investment) | | | | |
| Success Ratio | 0.6000 | 0.1000 | 0.6000 | 0.8000 |
| RMSE | 20.9801 | 21.7207 | 26.0319 | 24.5926 |
| $\phi_i^x$ | 0.3021 | 0.2818 | 0.1962 | 0.2199 |

**Note:** Success Ratio, that describes the percentage of instances in which simulated and observed data present the same sign; Root Mean Square Errors (RMSE's) between simulated and observed data; and $\phi$-statistics of the wedge component of the economic variable.